LASER COOLING

cience for the 21st Century ***will involve the continued research into the use of lasers for cooling***

Conventional wisdom holds that laser light directed at any object will heat rather than cool the object. Research at Los Alamos shows that under certain circumstances lasers can be used to efficiently cool objects. This research has advanced the field of optical cooling science and provided a basis for a future generation of novel refrigeration devices based on laser technology.

Laser, or optical, cooling is based on a principle of physics known as anti-Stokes fluorescence and occurs when the amount of energy emitted by a solid, when exposed to an energy source, is more than the energy it absorbs. In other words, a laser aimed at certain materials will excite the materials' atoms to a higher energy state. These excited atoms absorb a little extra energy from the heat of the surrounding material. When they produce photons, the photons are of a higher energy than the initial laser energy and this radiation of energy cools the material.

In 1995, a significant advance in the optical cooling of matter was made at Los Alamos when researchers for the first time used laser light to cool a solid. The sample comprised a glass compound doped with ytterbium (Yb), a rare earth element. Starting at room temperature, the earliest cooling experiment reduced the Yb sample's temperature by 0.5 degrees Fahrenheit. By the fifth year of research, the process had reduced the sample temperature by 117 degrees Fahrenheit, the current world record for laser cooling of solids. This groundbreaking work promises to push solid-state laser cooling of certain materials to even lower temperatures in future.

Other research at Los Alamos in laser cooling allowed the creation of LASSOR — the Los Alamos Solid-State Optical Refrigerator. LASSOR uses a 1.6-watt laser to cool fluoride glass doped with Yb a total of 97 degrees Fahrenheit starting from room temperature. Self-contained prototype LASSORs currently under construction utilize diode lasers with ten times this much laser power, dramatically increasing the cooling power.

With a bit more development, LASSORs and other laser cooling devices will be ideal for use in space, where they could cool a wide variety of detectors and instruments mounted on satellites to the temperature of liquid nitrogen and perhaps lower. Since laser coolers would be entirely solid-state devices, they would generate no vibrations and could survive unmaintained for years in the brutal environment of space.

In the future, laser cooling devices may even find uses in desktop computers where they could cool superconducting circuits, allowing the circuits to operate at speeds hundreds of times faster than today's conventional electronics without overheating.

Laser cooling is also playing an important role in some of the remarkable ultracold atom trapping research being conducted at the Los Alamos Neutron Science Center where scientists are trapping elusive atoms for close study.

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